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MULTIPLE RESERVOIRS IN THE MOFETE FIELD, NAPLES, ITALY

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ABSTRACT

Mofete field, located near Naples, in southern Italy, lies within the large Campi Flegrei caldera.
Drilling for geothermal fluids was carried out unsuccessfully in 1939-1954. AGIP, in joint venture with the national utility ENEL, after intensive exploration efforts, resumed drilling at the end of 1978; several new deep wells indicate the presence of a water dominated field in Mofete with three reservoirs (only the shallowest of which was reached by previous wells). The deepest aquifer, tapped by well Mofete 5 at the depth of about 2700 m, contains hypersaline fluids(about 516 000 ppm TDS at atmospheric conditions corresponding to about 150 000 ppm in the reservoir) with a bottom hole temperature of about 360°C. The intermediate level, reached by well Mofete 2 at 1900 m depth, is characterized by low salinity fluids (about 38 000 ppm TDS at the surface corresponding to 18 000 ppm calculated in the reservoir) with a reservoir temperature of 340°C. The uppermost reservoir, tapped by wells Mofete 1, 3D, 7D, 8D and 9D ranges between 550 and 1500 m depth and has water with salinity ranging from 40 000 to 76 000 ppm TDS at the surface corresponding to 28 000 to 52 000 ppm in the reservoir with a bottom temperature of 230-308°C. The uppermost aquifer is in fractured volcanic rocks while the other two are in a metamorphosed volcano-sedimentary complex.
Long term production and injection tests will be carried out shortly to ascertain the main characteristics of the field.

INTRODUCTION

Location

The Mofete field is located within the Campi Flegrei caldera, near Naples, in southern Italy (see Fig. 1). The caldera extends west of Naples for about 15 km. The Mofete field lies at the western limit of the caldera, along an isthmus between the Gulf of Pozzuoli and the Tyrrhenian sea. The area, occupied by low hills and with a mean elevation of 50-100 meters, is highly inhabited.

Summary history of exploration and development

Exploration for steam in the Mofete area began in 1939 where the local utility, through its geothermal subsidiary SAFEN, started exploration work interrupted by the war in 1943 and resumed in the years 1949-1954.
Several shallow and some deep wells were drilled, which indicated the presence of a hot salt water dominated system at shallow depth and temperatures as high as 325°C at a depth of 1800 m. The then existing techniques were not mature and the company abandoned its efforts. In 1978 AGIP, the Italian state owned oil & gas company, acting as operator, in joint venture with the national utility ENEL, was granted a lease and resumed the activities in the area. An extensive exploration programme was carried out which included geology, geochemistry, gravity and magnetic surveys, as well as some seismic lines.
The gravity data indicated a regional subcircular negative anomaly centered in the Gulf of Pozzuoli, surrounded by a ring of positive anomalies. Magnetically large positive anomalies are located offshore, as well as on land in the Astroni area of the positive gravity ring.
Most of the remaining positive gravity anomalies are characterized by negative magnetic anomalies (Fig. 2). The electric surveys show at shallow levels strong resistivity minima in correspondence to several areas, the origin of which is probably due to presence of hot saline waters (Fig. 3). The overall geologic interpretation of the geophysical picture (as shown in the interpretative schematic section in Fig. 4) is that of a ring of lava intrusions which locally have been altered by hot saline fluids rising through radial faults. The presence of such fluids is indicated by the low resistivity values which are coupled with a marked reduction of the magnetic susceptivity of the altered rocks.
The seismic results have been very poor and dif-

ficult to interpret.
The geochemical surveys indicate that the thermal waters of the Campi Flegrei caldera are a mix of local meteoric waters and deep hot waters of marine origin with indications of local leakage of steam.
The first AGIP deep well, Mofete 1, was drilled in 1978 to the depth of 1606 m and indicated the presence of a water dominated reservoir at 500-900 m in fractured volcanics with large quantities of saline water (43 000 ppm TDS, corresponding to 30 000 ppm TDS at reservoir conditions) with a temperature of 247°C.
Uncommercial quantities of fluids (65 000 ppm TDS at surface, corresponding to 39 500 ppm in the reservoir) were produced from below 1223 m.
Well Mofete 2, drilled in 1979 (500 m NW of well n° 1) to TD 1989 m has encountered in fractured volcano-sedimentary rocks (around 1300 and 1990 m) saline fluids (38 000 ppm TDS, corresponding to 18 200 ppm at reservoir conditions) with a temperature of 337°C.
AGIP subsequently completed the deep well n° 5, at TD 2700 m, and the directionally drilled n° 3D, 7D, 8D and 9D at depths between 907 and 1909 m; deviated drilling was carried out in order to make the best use of the limited available land in this highly inhabited region.
Well n° 5 produced for a short period from 2700 m very hypersaline fluids (over 500 000 ppm TDS at atmospheric conditions corresponding to about 150 000 ppm in the reservoir) at a bottom hole temperature of 347°C. Well 3D, 7D, 8D and 9D tapped the Mofete 1 reservoir between 500 and 1500 m vertical depth (with a bottom temperature of 230-308°C and an average salinity of 40 000-76 000 ppm TDS at atmospheric conditions, corresponding to 28 000-52 000 ppm in the reservoir).

GEOLOGY

The Campi Flegrei caldera, on the western flank of which is located the Mofete field, has a diameter of 15 km. The core of this large geologic feature lies in the sea (Gulf of Pozzuoli) and only its northern half is preserved on land, albeit substantially modified by collapses, sea ingressions followed by emergence and local volcanic episodes.
The latest volcanic event is the formation of the Monte Nuovo volcano in 1538, but the continuing strong ground deformation episodes and connected microseismic events indicate a permanent underground activity due to magmatic and phreato-magmatic phenomena. Fumaroles and hydrothermal activity are recorded on the sea bottom in the Gulf of Pozzuoli, as well as on land at the Solfatara, at Agnano and in the Mofete area. Outcrops in Mofete area consist of volcanics ("yellow tuffs"). In this area faults with WSW-ENE, N-S and NNW-SSE directions have been located either through direct examination or by interpretation of an elongated area of altered outcrops. Circular structures of volcanic origin abound in and around Mofete.
The subsurface, as indicated by the wells drilled, consists in volcanic and volcano-sedimentary rocks. The lithologic succession and relevant thickness, from top to bottom, is as follows (see Fig. 5):

1) Yellow, green and gray tuffs: 180-590 m.
2) Tuffs of marine origin with some interbedded lava beds: 500-800 m.
3) Trachitic-latitic lavas (10-550 m).
4) Tuffs with interbedded quartzitic-feldspathic siltites: 500-600 m.
5) Trachitic-latitic lavas with interbedded tuffs and siltites (deep section in well Mofete 5): 800 m.

There are no clear marker beds and therefore correlation between wells is extremely difficult. From the hydrothermal paragenesis point of view, the following zones and relevant alteration minerals can be detected (depth ranges of top of zone in brakets).

- argillitic zone (outcropping): montmorillonite, zeolite, calcite;
- phyllic zone (250-400 m): chlorite, calcite;
- phyllic-propylitic zone (500-800 m): chlorite, illite, calcite, adularia, epidote, pyrite;
- propylitic-potassic zone (850-1300 m): quartz, calcite, illite, adularia, calcite, epidote;
- low rank thermometamorphic zone (1700-2200 m): actinolite, diopside, tourmaline, garnet, pyrrhotite.

The hydrothermal minerals in the lowermost section (presence of garnet) are indicative of temperature above 320°C, whilst the propylitic epidote-bearing zone should indicate a temperature of 240-260°C. The depth of the various alteration zones varies with location: well n° 2 is the more strongly altered and at shallower depth than the other wells, while n° 5 shows the less alteration.

FIELD DESCRIPTION

Reservoirs

A shallow zone from surface to a depth of a few hundred meters is highly permeable. Below it, tuffs, alterated to argillaceous and argillaceous phyllic rocks, provide an adeguate caprock also through self sealing processes, due to hydrothermal circulation. The deeper section is still basically impervious except when fractured zones provide sufficient permeability to act as reservoir. As indicated, rocks are generally compact and permeability is mainly due to faulting and fracturing. Therefore the location of the reservoirsis erratic and unpredictable. Core examination has indicated the existence of fractures with inclination from 45° to subvertical; such fractures are frequently cemented by hydrothermal minerals such as illite, chlorite, epidote and quartz. Open fractures are indicated by loss of circulation zones, sometimes very conspicuous; potential productive zones are shown by temperature logs.

In well n° 1 total loss of circulation was encountered at 300-450 m, and partial losses at 850 and 1450 m. Temperature logs show from 600 to 1000 m and between 1200 and 1400 m isothermal zones which could be fluid bearing. Finally at 1550 m a sharp temperature reversal could be due to water influx. Tests have confirmed water bearing reservoirs at 600-1000 m and at 1223-1606 m.

Well n° 2 incurred severe losses of circulation in the 1300-1400 m interval and at 1950 m. Temperature logs show a zero increase at 1300-1350 m and between 1900 and 1989 m. Tests of the interval 1272-1989 m indicate one or more producing levels, possibly in corrispondence with the lost circulation zones at the top and bottom of the interval.

Well n° 3D, which encountered a conspicuous loss of circulation zone at 250-400 m, has an isothermal profile between 400 and 700 m (with a temperature decrease at 600 m) and between 1300 and 1450 m. Tests below 1297 m had negative results, while the perforated interval at 440-665 m is a poor producer, possibly due to formation damage and to the presence of two separate productive levels at different temperature (higher in the upper level) thereby creating an interference and thus showing an intermittent production pattern.

In well n° 5 formation were tight, even in the lowermost section, in which during a short production test a flow of highly saline brine could not be sustained.

Wells 7D, 8D and 9D show evidence,on the basis of fluid chemistry and testing, of a substantial common reservoir at 500-1500 m (vertical depth), which is the same shallow reservoir of wells 1 and 3D. In well n° 7D substantial losses of circulation were met at a deviated depth of 1250-1411 m (1100-1300 m vertical depth); the top of such zone is permeable from the temperature log interpretation.

Well n° 8D has a good permeability at 600-700 m deviated depth (515-650 m vertical depth).

In well n° 9D there is a highly permeable interval at 750-790 m deviated, corresponding to 720-760 m vertical depth. A deep level (1042-1648 m) produced limited amounts of brine.

Temperature distribution

Several temperature logs were run in the various wells. Although different instruments were used, the main tool has been the Amerada-Kuster recorder. The logs selected for an estimate of the equilibrium temperature of reservoir are in general the ones which were run as long as possible after the end of circulation or testing. For the purpose of locating the permeable zones, the temperature logs run shortly after completion of drilling were considered.

An example of temperature profiles interpretation in the Mofete field is hereafter given for well n° 1 (Fig. 6). The temperature profile immediately after drilling (prof. 1) shows two zones of likely convection, at the depths of 550-950 and 1200-1400 m; at both depths some minor losses of circulation occurred.

By the time this profile was run, the shallower horizon was already cased off, since higher temperatures were encountered at greater depth. The well was completed at the deepeer horizon, with a 5" slotted liner.

The equilibrium temperature profile (prof. 2) two months after the end of drilling, again shows the same convective horizons, but confirming the shallow and minimizing the deepeer one. After displacement with nitrogen, the well proved fluid inflow from the deepeer horizon at a limited flow-rate. The well was therefore perforated at the shallower horizon (550-896 m)obtaining a good production; even though the reservoir temperature was lower than that of the previously tested zone, its well head temperature was higher because of higher well head pressure due to higher permeability.

Table 1 - Mofete field - Maximum measured temperatures at equilibrium (°C)

	Well 1	Well 2	Well 3D	Well 5	Well 7D	Well 8D	Well 9D
Shallow reservoir	247	-	230-275	-	301	234	210-308 (°)
Intermediate reservoir	-	337	-	-	-	-	-
Deep reservoir	-	-	-	347	-	-	-

The temperatures measured in the wells (Table 1) are in good agreement with the temperatures derived from mineral alteration studies and with Na^+/K^+ geothermal data (except for well n° 5). The highest gradient is shown by well n° 2 with almost 340°C at 1989 m (TD), whilst the highest

(°) - Temperature recorded during drilling (not stabilized).

temperature was measured in well n° 5 at 2700 m (347°C). Isotherm maps (Fig. 7) clearly indicate a closed round anomaly with a radius of 0.5 km near surface, centered on wells 2 and 3D. The shallow isotherms show a culmination in correspondence to well n° 3D with 150°C at a depth of only 200 m. Well n° 3, deviated to the west, has shown evidences of a temperature plume with a decrease in temperature at about 600 m.

Fluid characteristics and theoretical model of the field

Chemical composition of the brine was measured at atmospheric pressure and is given in Table 2 hereunder; however data were also calculated at reservoir conditions for some selected wells (see Table 3). As can be seen from the chemical data, the composition and ratios of elements in well n° 1, shallow pay, are similar to those of the fluids tapped in well 3D, 7D, 8D and 9D.
An increase of salinity with depth is recorded in the wells n° 1 and n° 9D brines. Such increase can be due to the higher formation temperatures, which rise with depth from 230 to 308°C. As concern comparison of the brines of the shallow pay with those of the intermediate pay of well n° 2, some ratios, like Na/Cl, point to a common origin. However the much lower salinity of n° 2 well brines at the same depth and at a short distance from the deeper part of the shallow aquifer can be explained by considering the two reservoirs separated.
The brines of the deep section in well n° 5 are conspicuously different from the rest; water-rock interaction could have played a role.
A possible model of how the Mofete field originated, taking into account fluid chemistry and other elements, can be envisaged as follows: in a first deep reservoir (evidenced in well Mofete 5) the original sea water brine was concentrated to the present values because of evaporation due to the effect of the high temperature and limited recharge; consequently there was a loss of steam which migrated to the upper reservoirs. During its ascent the steam entered into the Mofete 2 reservoir and by condensing, because of lower temperature, caused a consistent dilution of the Mofete 2 brine which again one must suppose poorly connected with the seawater recharge zone. A very minor quantity of steam remained to alter only marginally the upper reservoir (wells 1, 3D, 7D, 8D and 9D) better connected with the sea, and to escape at surface.

Pressure distribution

Pressure was measured by different tools with the main instrument used being the Kuster-Amerada recorder. A reconstruction of the static pressure versus depth (see Fig. 8) with measurements recorded in each well in correspondence to the different reservoir levels, shows a common line corresponding to the hydrostatic pressure line, except for the points related to well n° 5 wich are shifted towards higher pressures. We therefore conclude that the reservoir of all wells (except n° 5) are interconnected and in communication approximately at sea level.

WELL LOGGING AND TESTING

Well logging

Since Mofete field is in volcanic formation, reliability of conventional electric logs is problematic; in effect a calibration for quantitative estimate of petrophysical parameters is not available at the moment. A complete set of logs was run in the first wells in order to examine the possibility of an integrate interpretation of the data. The interpretation led to a reduced log programme including DLL, GR, SP, BGT, DDDHC, HTT; the GR log has proved particularly useful to recognize the lithology and the other logs to detect the fractured layers.

Well testing

Up to now, only short tests have been carried out on Mofete wells, with a maximum amount of liquid discharged at surface of about 5000 m^3 per test (due to the pit dimensions). In the course and at the end of drilling, tests were at first carried out through drill strings (DST); these tests, later abandoned, provided results which permitted to select possible pay zones, even though only on a qualitative basis. A test that has been commonly used, during and at the end of the drilling, has been the injectivity test; this test is conducted whenever potential interesting intervals are indicated by temperature trends, circulation losses and mineral alterations. The procedure for injectivity test is as follows: (1) Injecting for short periods (15 min each) at different flow rates in order to be able to select a proper flow rate for a prolonged injection; (2) injecting at the selected flow rate, observing pressure build-up for 12 hours; (3) stopping injection and observing fall-off for 12 hours. Opposite the intervals selected for production, slotted liners are installed to prevent well sloughing. The wells are discharged, with the drilling rig still on site, through a test line which includes a silencer and allows to obtain the production parameters (flow rate, enthalpy, pressures, temperatures) with the Russel James method. Other parameters, like the transmissivity and skin factor, are obtained by pressure build-up and drawdown. These tests are generally short lasting, because of the limited volume of storing pits and provide only preliminary data. In some cases, when a potential production zone has been cased-off because a deeper pay was the target but its test was unsuccessful, casing was perforated by shaped charges. Notwithstanding the method is not the optimal for geothermal production, it was successful in the case of Mofete 1 well; shooting density was of 13 charges per m, from 550 to 896 m depth, resulting in a commercial production.

Once the drilling rig has been moved, beside the measurements with the Russel James method, in some wells (Mofete 1, 2) a pressure separator was used to allow production measurements and sampling of the two separated phases with more accuracy (Fig. 9). At the end of the production test, when the well was shut-up, a pressure build-up was carried out with a bottom-hole gauge, while initial draw-down could be conducted only when nitrogen displacement to induce the well was not necessary.

In Table 4 the data and the results of tests conducted in the field are indicated.

As can be seen from the above mentioned table, the upper reservoir has an enthalpy of 1100 kJ/kg while the intermediate one has 1600 kJ/kg. The transmissivity of the upper reservoir (20E-9 m^3/Pa s) is higher than the one of the intermediate reservoir (4E-9 m^3/Pa s).

The reservoir fluid in Mofete field, under static conditions, is single phase (liquid), with a dissolved CO_2 content varying from 1% to 5% by weight with the exception of well n° 2 reservoir in which the CO_2 was calculated to be flashed at static reservoir conditions.

The thermal and hydrogeologic conditions cause a two-phase state in the reservoir under dynamic conditions, because of pressure losses leading to evaporation. As a consequence the two phase fluid increases its enthalpy in its way towards the wellbore (since the rocks at a higher temperature transfer heat to the cooler boiling fluid) and upflows at nearly constant enthalpy (a slight decrease is due to work against gravity and to heat losses) whithin the wellbore (fig. 10). Because of CO_2 content, the fluid state is actually two-phase, two component, with the liberated CO_2 being present at slightly higher pressures than H_2O vapour.

FUTURE PROGRAMS

The next step foreseen consists of the evaluation of the size and behaviour of the reservoir and of the complementary corrosion and scaling studies. For the development of this state of experimentation it is necessary to put a well into long term production; the separated liquid will be disposed off by reinjecting it into another well.

To conduct the long term production-reinjection tests, two wells drilled from the same platform have been selected, to avoid installing long pipelines between platforms in the highly urbanized area of Mofete.

Wells n° 1 and n° 7D were selected as production and reinjection wells respectively, both in upper reservoir; 3 other wells will serve as observers for pressure interference. They are n° 2, in the intermediate reservoir, and n° 8D and N° 9D in the upper reservoir. During these tests the productive and reinjective performances of the wells will be observed for a period of 2 months; the hydrothermal conditions of the wells will be determinated to evaluate possible production regimes and to create the basis for a techno-economical evaluation of the field exploration. Moreover, the feasibility of reinjecting the separated liquid will be verified at selected temperatures, chosen on the basis of actual computation of the deposition kinetics of various elements, to avoid the scaling at the surface and in the reservoir.

The test plant was designed according to the scheme indicated in Fig. 11 with the purpose of allowing continuity of operations, flexibility of operating condition, bleeding of the fluids for chemical testing and accurate measurements of the flow rates. The second separation stage is foreseen to feed the chemical testing section at different temperatures independently from the temperature in the reinjection line. Injection of chemical inhibitors is foreseen, and several point of injection and sampling are envisaged to control the fluids, with various dosage units available. Corrosion tests are planned with the aim of finding out the most suitable materials for the future plants; they will be carried out not only on liquids but also on steam with the use of specimens and spools.

Immediately after the long term test and on the basis of results obtained, work-overs are planned to be carried out on some wells of the field. For instance, the well n° 9D, that in the course of drilling has encountered an upper interval with a good transmissivity, is actually completed in a deeper interval with poor productive characteristics; therefore the upper interval shall be opened to the production, perforating the casing with shaped charges. The wells 7D and 8D will be again put into production and the fluid will be reinjected for the time necessary (10-12 day) to evaluate their stabilized characteristics.

Moreover a research program of stimulation in-

terventios is being completed and a pilot stimulation job could be carried out by mid 1984 in well n° 3D (perforated interval 430-665 m). The testing program will provide the main information for the installation of a small plant for the experimental generation of electric energy. It is thought that a back pressure turbogenerator of 3 MW can be installed at the end of 1984. If such activity is successfull frilling of new wells both for production and reinjection purposes will be carried out both from the existing pads and from new ones mainly through deviated wells.
Concurrently a first commercial power plan of 15-20 MW could be installed in the next few years.

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REGIONAL MAP WITH LOCATION OF MOFETE FIELD

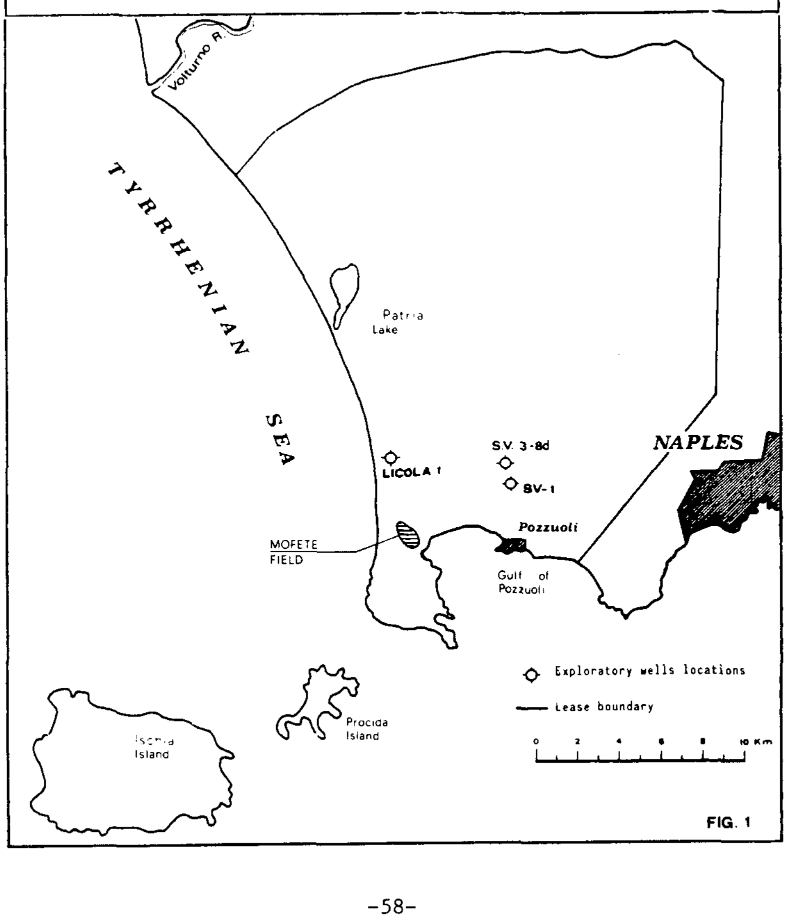


FIG. 1

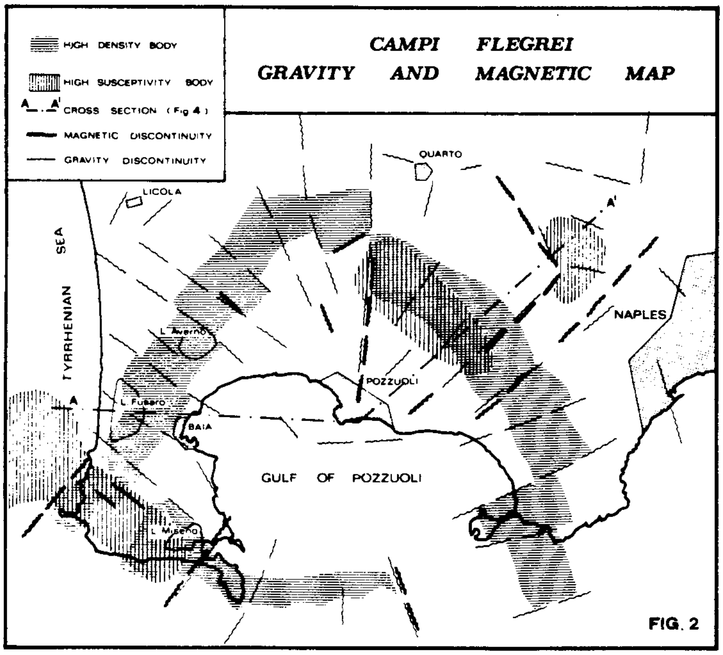

HIGH DENSITY BODY
HIGH SUSCEPTIVITY BODY
CROSS SECTION (Fig 4)
MAGNETIC DISCONTINUITY
GRAVITY DISCONTINUITY
CAMPI FLEGREI
GRAVITY AND MAGNETIC MAP
QUARTO
LICOLA
TYRRHENIAN SEA
NAPLES
L. Averno
POZZUOLI
L. Fusaro
BAIA
GULF OF POZZUOLI
L. Miseno
A
A'

FIG. 2

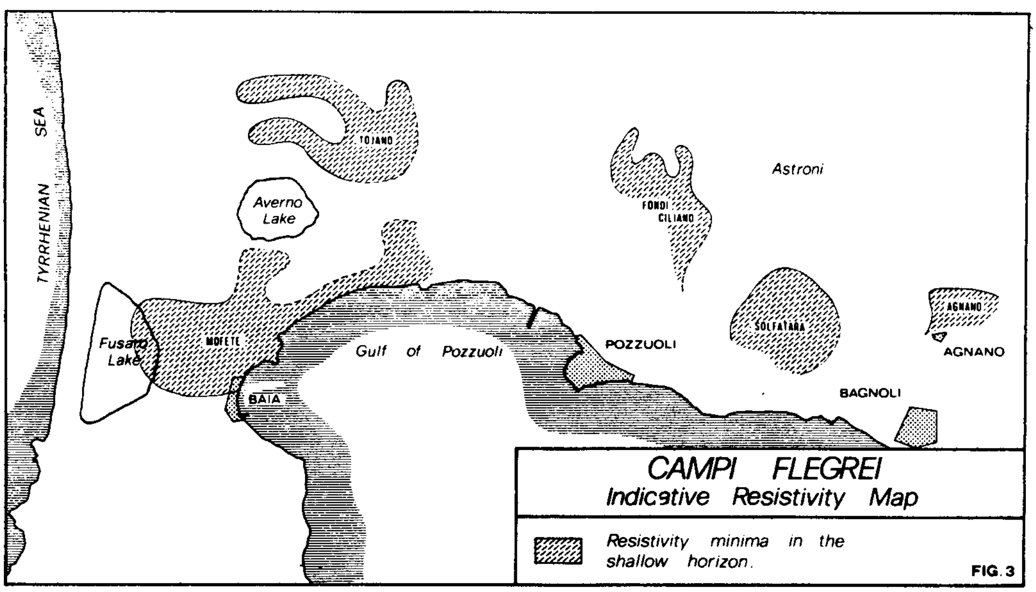
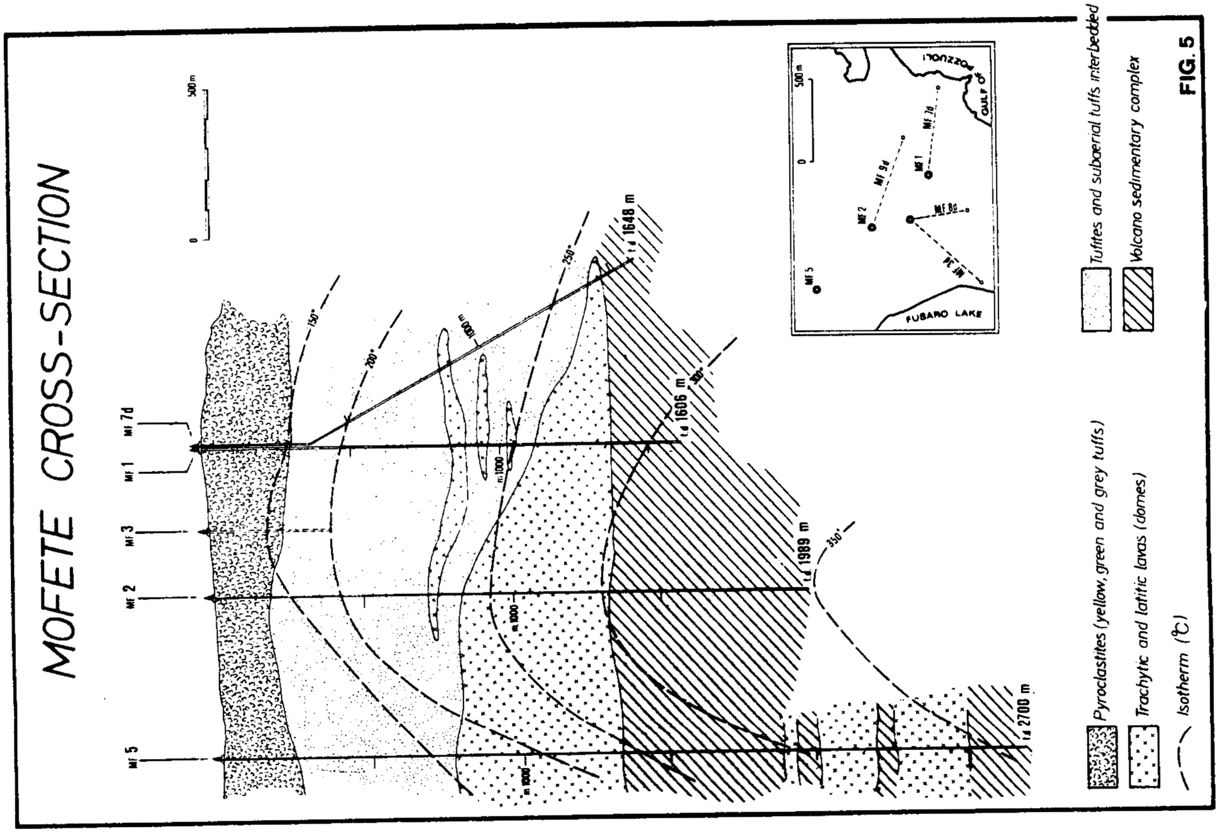
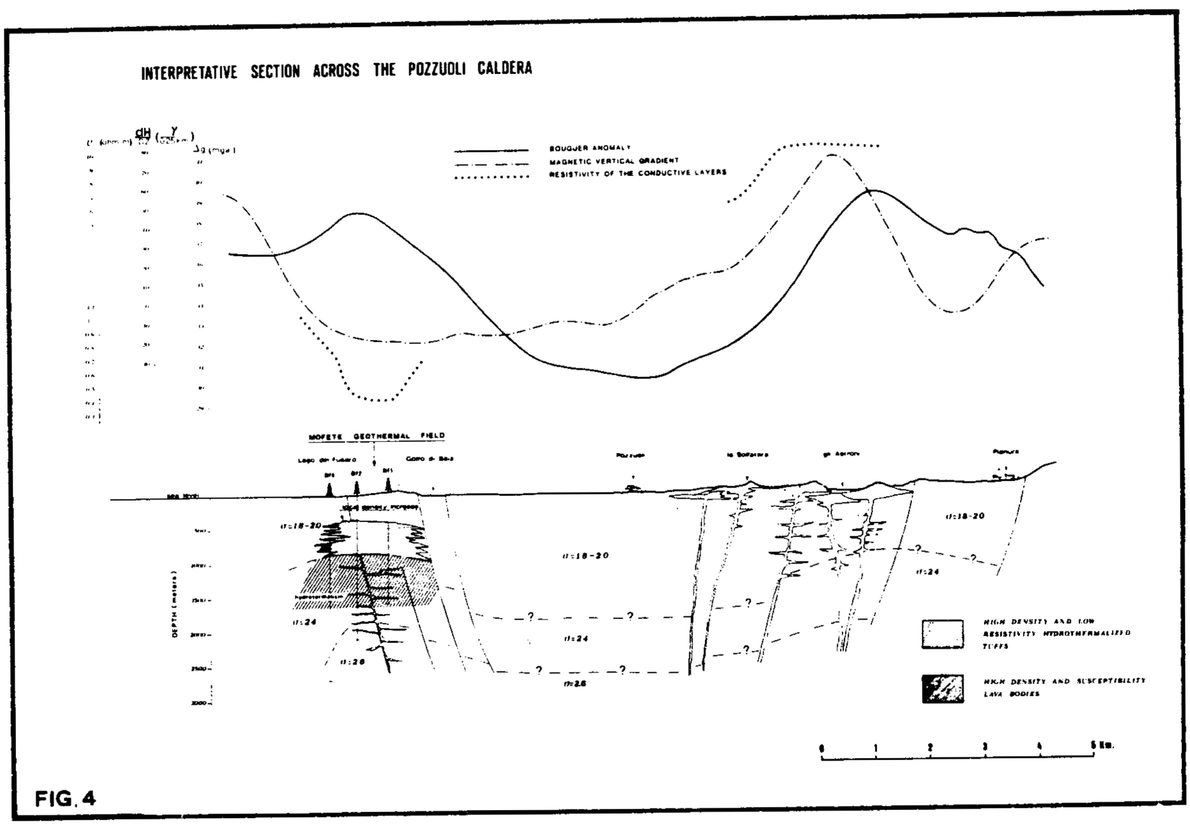

TYRRHENIAN SEA
TOIANO
Astroni
FONDI CILIANO
Averno Lake
Fusaro Lake
MOFETE
Gulf of Pozzuoli
POZZUOLI
SOLFATARA
AGNANO
AGNANO
BAGNOLI
BAIA
CAMPI FLEGREI
Indicative Resistivity Map
Resistivity minima in the shallow horizon.

FIG. 3


MOFETE CROSS-SECTION
Pyroclastites (yellow, green and grey tuffs)
Trachytic and latitic lavas (domes)
Isotherm (°C)
Tuffites and subaerial tuffs interbedded
Volcano sedimentary complex
FUSARO LAKE
GULF OF POZZUOLI
FIG. 5


INTERPRETATIVE SECTION ACROSS THE POZZUOLI CALDERA
BOUGUER ANOMALY
MAGNETIC VERTICAL GRADIENT
RESISTIVITY OF THE CONDUCTIVE LAYERS
MOFETE GEOTHERMAL FIELD
HIGH DENSITY AND LOW RESISTIVITY HYDROTHERMALIZED TUFFS
HIGH DENSITY AND SUSCEPTIBILITY LAVA BODIES
FIG. 4

WELL MOFETE 1
STATIC TEMPERATURE PROFILES

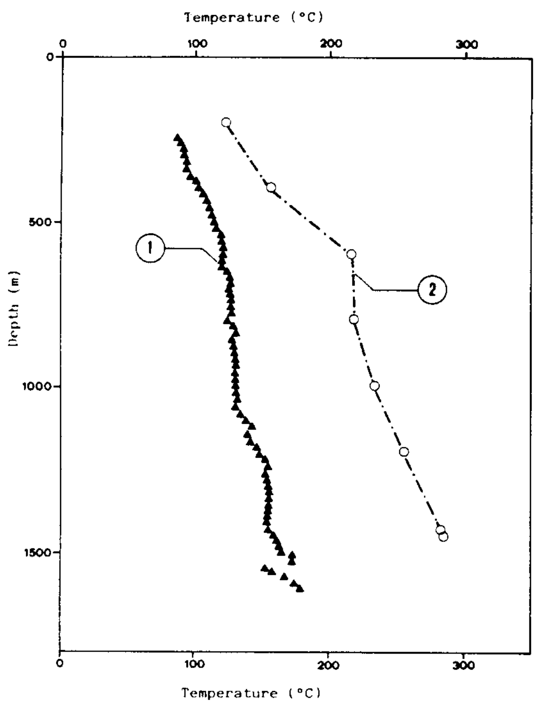


FIG. 6

MOFETE FIELD ISOTHERMS (°C)

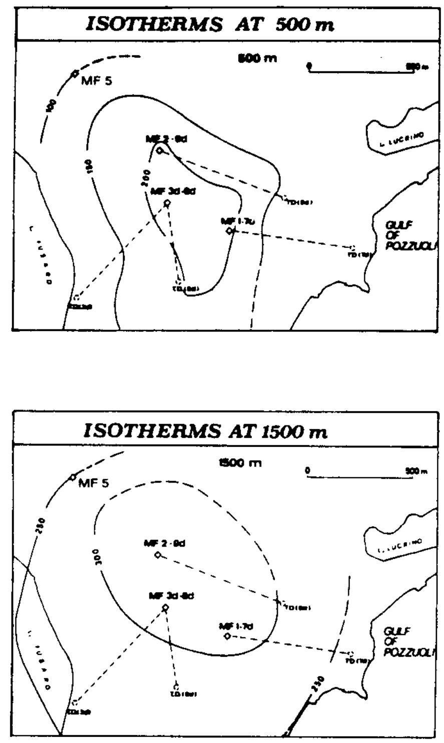


FIG. 7

MOFETE FIELD
PRESSURE-DEPTH RELATIONSHIP

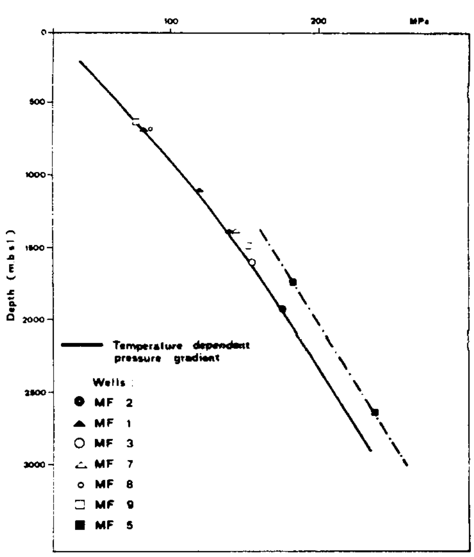


FIG. 8

MOFETE PIT-TEST UNIT
WITH PRESSURE SEPARATOR

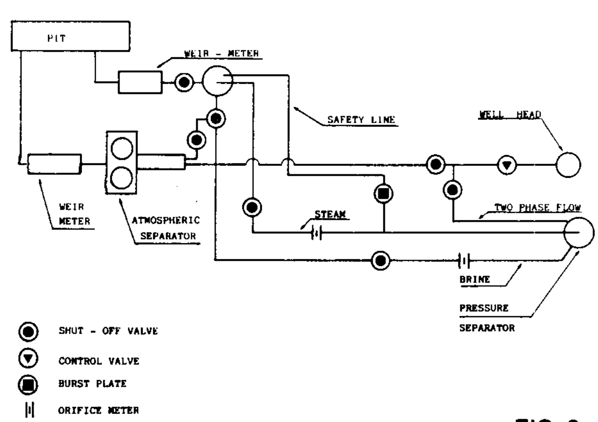
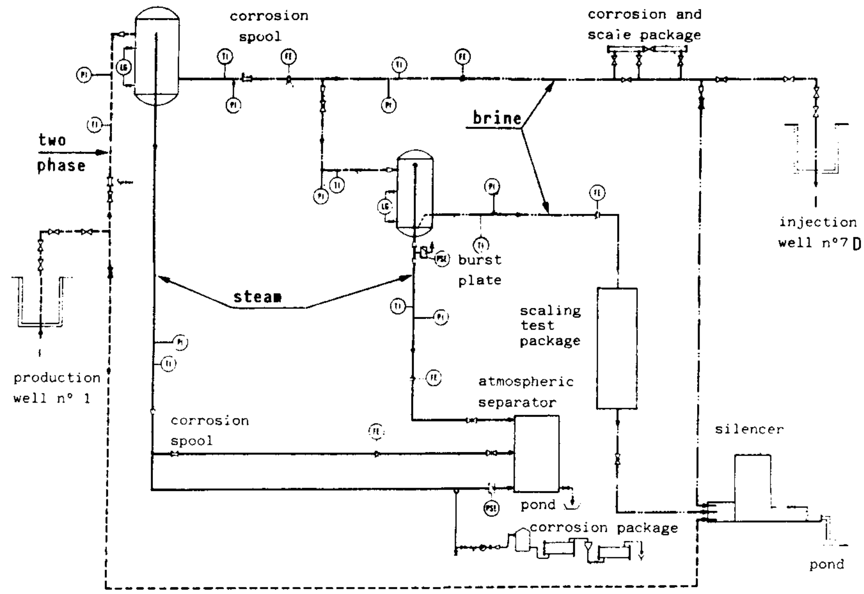
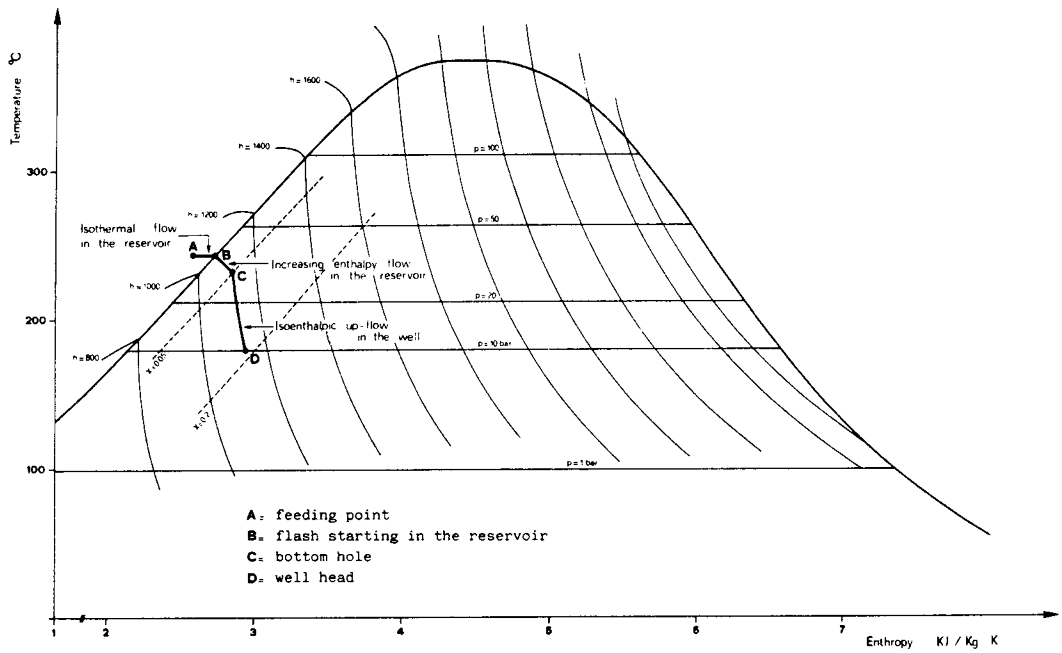


FIG. 9



Mofete Field
Long term test unit

FIG. 11



Mofete Field:
Thermodynamic pattern from reservoir to well head

FIG. 10

TABLE 2

MOFETE FIELD

CHEMISTRY OF WATER SEPARATED AT ATMOSPHERIC PRESSURE (ppm)

	Shallow Reservoir						Intermediate Reservoir	Deep Reservoir
	Well N° 1 (550-896 m)	Well N° 1 (1273-1606 m)	Well N° 3D (430-665 m)	Well N° 7D (1110-1648 m)	Well N° 8D (662-907 m)	Well N° 9D (1339-1749m)	Well N° 2 (1275-1989m)	Well N° 5 (2310-2699 m)
Na	14320	20860	13790	14760	14590	21300	10600	85160
K	1760	3880	1122	2610	1626	4410	2467	43380
Ca	792	2124	714	790	752	3520	1005	53950
B	178	183	106	144	90	288	295	231
Sr	49	68	43	26	41	64	30	1310
As	13	17	16	26	15	32	22	-
Li	36	46	34	56	37	56	28	480
Mn	10	28	4	10	8	55	52	5510
Fe	1	3	3	21	1	2	1	9450
SiO_2	568	690	425	639	454	578	938	210
Cl	25304	37800	23393	26650	25171	43897	21169	313850
HCO_3	116	77	110	195	98	73	85	TRACES
SO_4	72	7	156	70	82	14	12	TRACES
TDS	42860	65509	39428	45997	42965	75695	37880	515902
Na/Li	398	453	406	264	394	380	379	177
Cl/B	142	207	221	185	280	152	72	1359
Na/Cl	0.57	0.55	0.59	0.55	0.58	0.49	0.50	0.27
pH	7.5	6.5	7.5	7.2	7.7	6.9	6	4.5

TABLE 3

MOFETE FIELD

WATER CHEMISTRY FOR SELECTED SAMPLES CALCULATED AT RESERVOIR CONDITIONS (ppm)

	Shallow Reservoir		Intermediate Reservoir
	Well N° 1 (550-896 m)	Well N° 1 (1273-1606 m)	Well N° 2 (1275-1989 m)
Na	10025	12589	5090
K	1230	2342	1180
Ca	555	1281	480
B	125	110	140
Sr	34	41	14
As	9	11	11
Li	25	28	13
Mn	7	17	25
Fe	1	2	1
SiO_2	398	417	450
Cl	17710	22810	10200
HCO_3	81	46	41
SO_4	50	4	6
TDS	30000	39500	18200
Na/Li	398	453	391
Cl/B	142	207	73
Na/Cl	0.57	0.55	0.50

TABLE 4

RESULTS OF TESTING OF MOFETE WELLS

WELL (total depth-m)	INJECTION					PRODUCTION					
						LIP METHOD			PRESSURE SEPARATOR METHOD		
	TESTED INTERVALS (m)	INTERVAL TEMPERATURE (°C)	W H P (MPa)	FLOW RATE (m^3/h)	TRANSMISSIVITY ($m^3/Pa\ s$)	RELEVANT DATA	ENTHALPY (kJ/kg)	TRANSMISSIVITY ($m^3/Pa\ s$)	RELEVANT DATA	ENTHALPY (kJ/kg)	TRANSMISSIVITY ($m^3/Pa\ s$)
MOF 1 (1606 vert.)	550-896 csg 7"-9" 5/8	247	-	-	-	WHT=220°C WHP=2.35 MPa Q_s = 25 t/h Q_t = 70 t/h	1100	-	WHT=220°C WHP=1.27 MPa Q_s = 31 t/h Q_t = 210 t/h	1100	-
	1223-1469 liner 5"	295	-	-	-	WHT=165°C WHP=0.49 MPa Q_s = 9.5 t/h Q_t = 24 t/h	1100	-	WHT=140°C WHP=0.4 MPa Q_s = 7 t/h Q_t = 23 t/h	1100	$0.5x10^{-9}$
MOF 2 (1989 vert.)	1272-1989 liner 7"	337	3.86 4.90 5.90	36 55 95	6×10^{-9}	WHT=200°C WHP=0.52 MPa Q_s = 35 t/h Q_t = 61 t/h	1600	-	WHT=200°C WHP=0.92 MPa Q_s =27 t/h Q_t =66 t/h	1600	$4.7x10^{-9}$
MOF 3d (1909 dev. 1749 vert.)	430-665 csg 9"5/8	230	-	-	-	LOW PRODUCTION		-	-	-	-
	1302-1900 liner 7"	275	3.5 3.5 3.8 4.9	27 87 126 162	$0.7x10^{-9}$ $0.6x10^{-9}$ $0.6x10^{-9}$ $1.1x10^{-9}$	NO PRODUCTION		-	-	-	-
MOF 5 (2700 vert.)	1627-1960 liner 7"	286	3.5	60	$0.5x10^{-9}$	LOW PRODUCTION		-	-	-	-
	2310-2699 liner 5"	362	7.03	19	$0.7x10^{-9}$	VERY FAST SALT DEPOSITION INTERRUPTS PRODUCTION		-	-	-	-
MOF 7d (1648 dev. 1476 vert.)	1042-1646 liner 7"	301	0.1 0.6 0.8	38 133 181	$10x10^{-9}$	WHT=165°C WHP=0.68 MPa Q_s =20 t/h Q_t =60 t/h	1150	$5x10^{-9}$	-	-	-
MOF 8d (907 dev. 800 vert.)	660-907 liner 7"	234	0.1 0.45 0.17	36 61 95	$20x10^{-9}$	WHT=155°C WHP=0.89 MPa Q_s = 18 t/h Q_t = 200 t/h	950	$17x10^{-9}$	-	-	-
MOF 9d (1745 dev. 1582 vert.)	694-1004 O.H. 12"1/4	210	0.8 1.4	54 115	$22x10^{-9}$	NOT YET TESTED		-	-	-	-
	1342-1745 liner 7"	308	0.1 4.3 4.5	9.5 39 83	$2x10^{-9}$	LOW PRODUCTION		-	-	-	-